Overcoming Threshold Concepts in Undergraduate Physics

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Research Goals

- 1. To characterise and find examples of threshold concepts in undergraduate physics
- 2. To identify, if it exists, a commonality in process of overcoming threshold concepts
- 3. To guide future teaching of threshold concepts

Motivation

- Overcoming threshold concepts is crucial to mastery of subject
- Identifying threshold concepts to guide teaching has had success in other disciplines (e.g economics)

 This research is motivated by a desire to characterise threshold concepts in physics and to determine how best to overcome them

Background

- Threshold concepts within a discipline are concepts that are required to be understood in order to progress.
- Theory: a way of breaking things down to understand how succesful learning occurs
- Overcoming a threshold concept can be seen as a transformation

General Process of transformation

Pre-liminal

Encounter Troublesome Knowledge



Liminal
Integration
Discarding
Ontological
and
Epistemic Shift

Post-Liminal
Transformation
Irreversibility

Crossed conceptual boundaries

Key Aspects of Threshold Concepts

Transformative

Overcoming a threshold concept changes the way a student thinks

Threshold concepts are likely to exist at the boundaries of sub disciplines. Overcoming them will illuminate connections between

areas in physics

Integrative

Threshold concepts are likely to be complex, alien and/or counter-intuitive

Challenging

Method: Qualitative Analysis

Select Participants

 8 PhD Students, evenly split between junior and senior years/ theoretical and experimental disciplines

Obtain Raw Data

- Record discussion with participant
- Take notes

Transcribe Interview

[1]

[2]

- Time consuming but crucial part of the research
- Allows data to be organised thematically

Data Analysis

- Identify mentions of concepts and test against aspects
- Identify mentions of methods
- Build up picture of process of transformation
- Refine interview

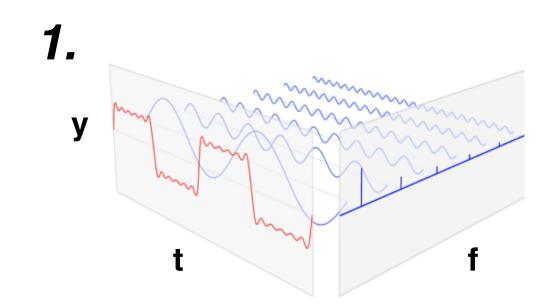
Draw Conclusions

 Use thematically organised data to draw conclusion from research

[4]

 Consider how university can respond to facilitate the process of transformation

Results: Concepts and Methods



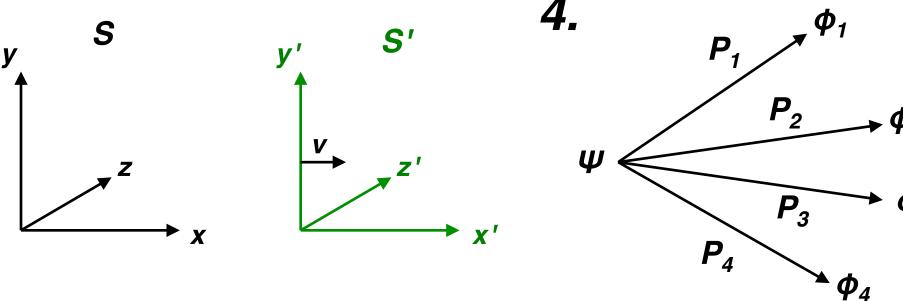
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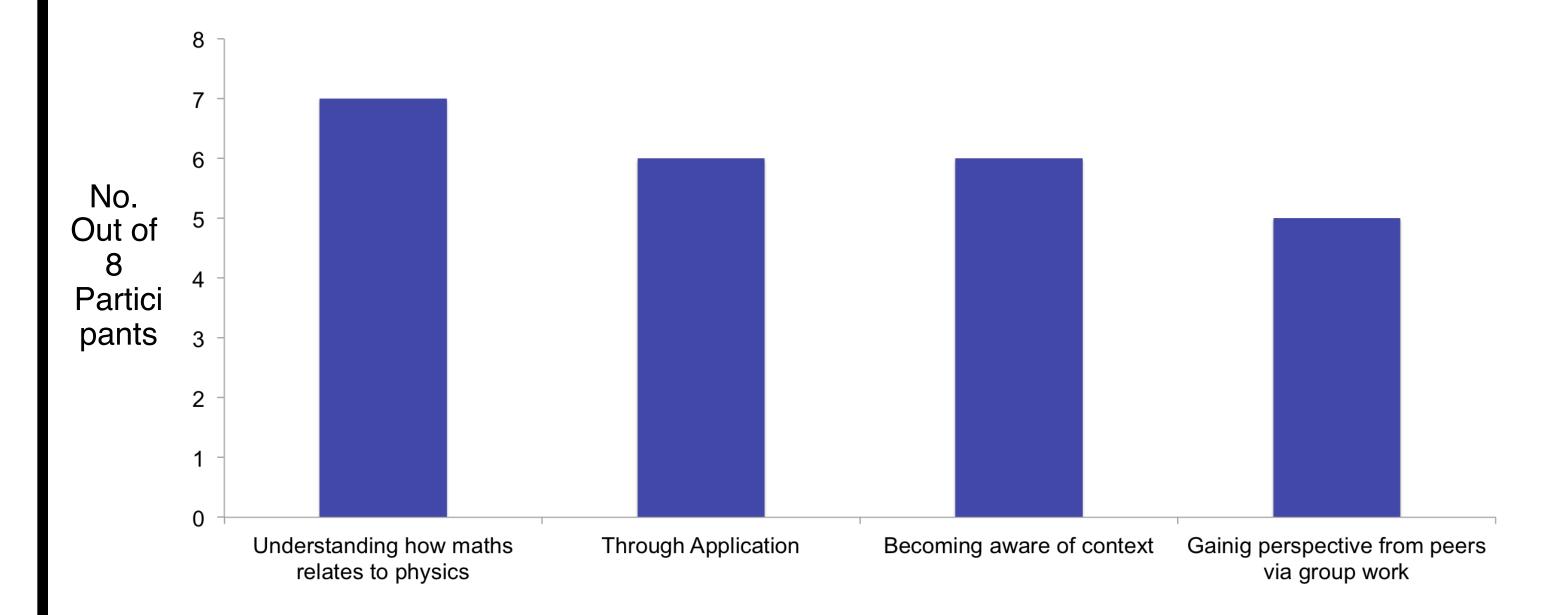
Selected Threshold Concepts Mentioned

- 1. Fourier Analysis
- 2. Lorentz Transformations
- 3. Maxwell's Equations
- A Born Bulo
- 4. Born Rule



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All 8 participants related to the experience of overcoming threshold concepts, however remembering specific concepts was not always possible. The graph characterises the most common methods employed to overcome threshold.



Liminal

- Intellectual threshold met
- Unable to think in correct way to understand concept
- Lacking Intuition

Pre-liminal

- See Concept in Application
 Gain Perspective from Peers in group
 Explain current
- Explain current position to peersNotice
- connectionsUnderstandrelevant maths toolsand how they relateto physics
- Gain new intuition

Post-liminal

- Intellectual threshold overcome
- Able to think in correct way to understand concept and beyond
- Able to notice connections between areas that were previously locked

Process of transformation specific to undergraduate physics (from data) i.e a summary of responses organised in terms of stages of transformation according to the literature.

Conclusions and Outlook

- Threshold Concepts are relevant to undergraduate physics courses
- Threshold concepts in physics can be characterised as transformative, integrative and challenging
- There is commonality in process of transformation
- Universities could better facilitate the process by using teaching time to apply knowledge, facilitating/encouraging more group work and highlighting context of concepts as part of a greater body of knowledge

References

- [1] Land et al, 2010, Threshold Concepts and Transformational Learning, Sense, pp. ix-xlii [2] Shanahan et al, 2008, Chapter 12 in Threshold Concepts Within the Disciplines, Land et al, 2008, Sense Publishers
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